

!AP20 Rec'd PCT/PTO 13 FEB 2006

**Vibratory Apparatus for Piles Comprising  
Bearings for Rotating Unbalanced Masses**

The invention relates to a vibratory apparatus for driving and extracting piles, comprising bearings for rotating unbalanced masses, said unbalanced masses being arranged in a bearing flange by means of a bearing journal and a bearing bush, or comprising bearings for shafts, on which the unbalanced masses are mounted.

In vibratory apparatus for mechanical driving and extracting piles, rotating unbalanced masses are used for generating vibrations, which are transmitted to the pile and thereby facilitate its penetration into the earth. The piles may comprise, for example, sheet piles, girders or steel tubes. The technique is primarily used for the construction of harbours and for securing deep construction pits against earth slippage. With the increased use of the technique, the piles used have also become heavier and larger. Correspondingly, the speed and static moment of the unbalanced masses have also been increased.

However, the roller bearings used for bearing the unbalanced masses have only limited suitability for high speeds, because their load bearing strength reduces with increasing speeds, so that roller bearings are only of restricted use for the development and production of larger and more powerful machines.

The object underlying the invention is to design a bearing for the unbalanced masses installed in vibration apparatus that permits the generation and transmission of unbalanced forces to the pile-like object at high speeds and also has a high load-bearing capacity.

In the case of a vibration apparatus equipped with pumps for circulating lubricating fluids, this object is achieved by means of bearings that are characterised in that

- the bearings are liquid-lubricated sliding bearings
- each bearing bush has at least two channels (bearing bush channels) extending in the radial direction
- each bearing bush has, on at least one end, groove-like depressions that extend in the radial directions or such grooves that are introduced into the axial running faces that lie against the bearing bush of the unbalanced masses or into the shafts that are supported in the sliding bearings,
- that surface of the bearing journal that surrounds the bearing bush or the shaft has one or more groove-like depressions,

The bearing according to the invention is a fluid-lubricated sliding bearing that consists of a bearing journal and a bearing bush. The bearing bush has two channels or more channels extending in the radial direction. The channels serve for conducting lubricating fluid to the bearing journal, which lies against the inside of the bearing bush and has one or more groove-like depressions on the surface thereof. Moreover, each bearing bush has, on at least one end, at least two groove-like depressions that extend in the radial direction and permit as far as possible resistance-free conduction of the lubrication fluid.

The gist of the invention is that hydrodynamic sliding bearings are installed to transmit the centrifugal forces, the bearing bushes of the fluid-lubricated sliding bearing having more than only one channel, lubrication grooves on the surface of the bearing journal supporting uniform distribution of the lubrication fluid, and channels on the face end of the bearing bushes rapidly draining away the lubricating fluid. Because of the feed pressure and the rotational speed, a thin liquid film forms between the bearing journal, which is surrounded by the bearing bush, and the bearing bush, and greatly reduces the frictional resistance between the bearing journal and the bearing bush. Lubrication grooves on the surface of the bearing journal promote the uniform distribution of

the lubricating fluid in the bearing. The channels provided on the face sides of the bearing bushes are dimensioned such that the lubricating fluid can be drained off with as little resistance as possible. This permits a high lubricant throughput and good heat dissipation.

The advantages of the vibration apparatus equipped with the sliding bearings according to the invention can be seen in the increased load-bearing strength of the bearings at high speeds. Because of the elimination of the roller cage, the intrinsic weight and mass moment of inertia of the sliding bearings according to the invention are much lower than a roller bearing of corresponding load-bearing capacity. The lower mass moment of inertia is particularly advantageous in "directed vibration", because a continually changing angular acceleration occurs. Furthermore, the use of hydrodynamically lubricated sliding bearings reduces the noise generated during operation of the vibratory apparatus and favours its use in residential areas.

As regards the construction, several possibilities are available according to the invention. In the illustrated exemplary embodiment, the bearing bush has eight channels extending in the radial direction, as well as a surrounding annular groove at the outside lying against the unbalanced mass flange. The in the radial direction inwardly leading channels (bearing bush channels) proceed from this groove. By means of the annular groove, it is ensured that the lubricating fluid that is fed through the channel in the unbalanced mass flange is evenly distributed across the entire exterior circumference of the bearing bush and can flow rapidly into the channels of the bearing bush.

It lies within the scope of the invention that at least one of the end faces in each bearing bush is designed as a running face. In a further development, these running faces have groove-shaped depressions in the radial direction. These depressions are intended to drain away the lubricating fluid with as little resistance as possible so that it can be

rapidly replenished with new lubricating liquid. It is of course conceivable, with an equally advantageous effect, that the grooves are accommodated, instead of in the running face, in those axial running faces that are adjacent to the bearing bush, of the unbalanced masses, or of the shafts that are supported in the sliding bearings.

That surface of the bearing journal that surrounds the bearing bush has at least one groove-shaped depression in the azimuthal direction and/or axial direction. This design of the bearing journal surface supports the rapid and uniform distribution of the lubricating fluid over the entire loading area of the bearing journal. The length of the groove in the azimuthal direction is dimensioned such that it extends over the openings of at least two adjacent bearing bush channels. The grooves extending in the axial direction terminate blindly and thereby prevent pressureless bleeding out of the lubricating fluid.

A bearing play between the bearing journal and bearing bush of 1-3/1000 of the bearing journal diameter is considered particularly favourable.

According to a further feature of the invention, copper/aluminium alloys, that is to day copper/aluminium cast alloys (DIN 1714) or copper/aluminium wrought alloys (DIN 17665) are used. The cast alloys are heterogeneous in structure and have good casting properties, while the wrought alloys are homogeneous in structure and have ductile properties. Both are characterised by high wear resistance.

Further details and features of the invention are explained below in greater detail with reference to examples. The illustrated examples are not intended to restrict the invention, but only to explain it. In schematic view:

**Figures 1 a-1 b** shows the bearing flange with installed bearing bush  
**Figure 1c** shows the bearing flange with bearing bush, bearing

- |                      |  |
|----------------------|--|
|                      | journal and unbalanced masses                  |
| <b>Figures 2a-2c</b> | show the bearing bush                          |
| <b>Figures 3a-3b</b> | show the ring with grooves for oil outflow     |
| <b>Figures 4a-4c</b> | show the unbalanced mass with bearing journal, |

Figure 1a shows the unbalanced-mass flange 1 with the inserted bearing bush 3 in top view. Figure 1b shows the two parts in cross section. The oil feed bore 2, which runs in the radial direction, can also be seen. On the bearing bush 3 can be seen five of the total of eight bores 4a-4e running in the radial direction. The bores 4a-4e in each case extend from an annular groove 5 on the outside of the bearing bush 3 and terminate at the inside of the bearing bush 3, so that there are connections for the lubricant between the oil-feed bore 2 and bearing journal 10. The unbalanced mass 11 joined to the bearing journal 10 is shown in Figure 1c after installation of the unbalanced mass flange 1. The unbalanced mass 11 is connected via bearing journal 10 to the unbalanced mass 12, which is located on the opposite side of the unbalanced mass flange 1. In the illustrated example, screws are used to produce this connection.

Figure 2a shows the bearing bush 3 in cross-section.

Figure 2b shows the running face 7 of the bearing bush 3. The running face 7 is characterised by four grooves 6a-6d, which extend in the radial direction and serve for resistance-free draining off of the lubricating fluid. The sectional view in Figure 2c shows eight bearing-bush channels 4a-4h extending in the radial direction. The bearing bush channels 4a-4h are supplied via the groove-like depression 5 located on the outside of the bearing bush while the rotation of the bearing journal is supplied evenly with lubricating fluid.

Figure 3 shows the ring 8, which serves for enlarging the second end running face of the bearing bush 3, shown in Figure 2c. The ring 8 show in top view in Figure 3b shows four groove-like depressions 9a-9d extending

in the radial direction. Ring 8 is fastened on the bearing bush after installation of the bearing bush 3 in the unbalanced mass flange 1. Like the groove-shaped depressions 6a-6d on the opposite end starting face of the bearing bush 3, the depressions 9a-9d serve for resistance-free draining off of the lubricant.

Figures 4a – 4c show the unbalanced mass 11, which is connected to the bearing journal 10. Figure 4c shows the lubricating grooves 13, 14 on the running face of the bearing journal 10.

List of Reference Characters

1. Unbalanced mass flange
2. Oil feed bore
3. Bearing bush
4. Bearing bush channels
5. Annular groove on the bearing journal /shaft
6. End-face grooves on the bearing bush
7. End running face on the bearing bush
8. Ring as second end running face
9. End-face grooves on ring
10. Bearing journal / shaft
11. Unbalanced mass with bearing journal,
12. Unbalanced mass
13. Lubricating groove on bearing journal
14. Lubricating groove on bearing journal